1986 Insect Pest Management Guide

STORED GRAIN

Grains produced in Illinois may be stored for periods of a few weeks to a few years before feeding or processing. The profitability of such storage depends not only upon marketing concerns, but also upon maintenance of grain quality. It is important to remember that the harvest and storage of grain does not signal an end to the possibility of losses caused by insects and pathogens.

Successful management of stored-grain insects is possible only when proper storage practices are carried out. Insecticides and fumigants should be viewed as supplements to, not replacements for, sound storage methods. Used properly, however, insecticides and fumigants can help to limit insect losses in stored grains without endangering the pesticide applicator or resulting in excessive pesticide residues that threaten the health of consumers (livestock or humans) of treated grain or grain products.

This publication provides recommendations for cultural and chemical control of stored-grain insects. It is revised annually; always use the current year's issue. Registration changes that occur between revisions will be announced to appropriate media sources and county Extension offices.

USING INSECTICIDES AND FUMIGANTS

The U.S. Environmental Protection Agency has designated certain pesticides for "restricted" use. The grain fumigants chloropicrin and aluminum phosphide are restricted-use pesticides. *Private* applicators who wish to purchase or apply restricted-use pesticides "for the purpose of protecting any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must obtain certification by passing an examination. The Illinois Department of Agriculture administers the certification procedure for private applicators. *Commercial* applicators also must be certified in order to apply restricted-use pesticides. Elevator employees responsible for grain treatment at their place of employment must be certified under the category "Grain Facility Pest Control Applicator." Commercial fumigation professionals who treat stored grain or grain products at farms, elevators, warehouses, etc. must be certified by the Illinois Department of Public Health.

Those who apply pesticides should be aware that the pesticide user is always responsible for the results of pesticide applications. To avoid accidents and maximize the effectiveness of any application, always read the pesticide label and follow all directions and safety precautions. Be sure that the pesticide is specifically labeled for the pest, site, and application method planned. Remember: THE LABEL IS THE LAW.

Poison Resource Centers. The Poison Resource Centers listed below have been established to provide information about the treatment of poisoning cases. Anyone with a poisoning emergency can call the toll-free telephone number for help. Personnel at the Resource Center will provide first-aid information and refer callers to local treatment centers if necessary.

Poison Resource Centers supplement, but do not replace, local emergency medical services. Do not delay calling local emergency medical personnel to request immediate assistance or transportation. If possible, have the pesticide container and label present when you call or reach a treatment center or hospital.

Chicago and northeast Illinois
1753 West Congress Parkway
Chicago, Illinois 60612
Telephone: 800-942-5969

Northern and central Illinois
530 N.E. Glen Oak
Peoria, Illinois 61603
Telephone: 800-322-5330

Central and southern Illinois
800 East Carpenter
Springfield, Illinois 62702
Telephone: 800-252-2022

NOTE: The information that follows is provided for educational purposes only. Reference to commercial products or trade names does not constitute an endorsement by the University of Illinois and does not imply discrimination against similar products. Trade names are presented for reasons of clarity only. The reader is urged to exercise the usual caution in making purchases or evaluating product information.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
Prepared by Richard A. Weinzierl, Extension Entomologist CIRCULAR 1242 November 1985

INSECTS ATTACKING STORED GRAIN

Several types of insects inhabit stored grain. Exact identification of these insects often is difficult because most stored-grain pests are extremely small ($\frac{1}{16}$ to $\frac{1}{4}$ inch in length), and many separate species are very similar in appearance. Presenting identification information for the many species of stored-grain pests is not the purpose of this publication; materials containing such information are included in the reference listing at the end of this circular. It is important, however, to recognize the different groups of insects that live in stored grains because management considerations may differ according to the insects' characteristics.

Weevils and Other Insects that Feed Inside Kernels

The most damaging insect pests of stored grain are those that develop within grain kernels. These insects are referred to as internal pests or primary pests. Adults deposit eggs on or in whole kernels, and larvae develop hidden within kernels. Damage caused by internal pests makes grain more suitable for infestation by insects that feed externally on grain or grain debris.

The common primary pests of grains in Illinois are the weevils — rice weevil, maize weevil, and granary weevil. The grain weevils are small (between $\frac{1}{16}$ and $\frac{1}{8}$ inch in length), but recognizable as a group because the head bears a prolonged snout. These insects may be found in any portion of the grain mass within a bin; they are not restricted to portions near the surface.

Beetles that Develop and Feed Outside Grain Kernels

Most insects commonly collected in stored grain in Illinois are beetles that range in size from $\frac{1}{16}$ inch to over $\frac{1}{2}$ inch in length. Adults of most species are reddish-brown to black in color, and their forewings are hardened to form a "shell" over the body. Larvae of common species are cylindrical and cream-colored; some bear fine hairs. Species frequently collected in Illinois grain bins include the sawtoothed grain beetle, flat grain beetle, rusty grain beetle, foreign grain beetle, hairy fungus beetle, larger black flour beetle, red flour beetle, and confused flour beetle.

Like the weevils, beetles that feed and develop outside grain kernels are not limited in distribution to the grain surface, but instead inhabit any portion of a grain mass. They feed on several different grains, but their buildup in any grain usually results from an abundance of broken kernels (fine material) or fungal growth on moist grain. Their dependence on fines or fungal growth accounts for the description of these insects as "secondary" pests, "bran bugs," or "fungus-feeders." Concentrations of stored-product beetles cause an increase in grain moisture and temperature, and such changes favor continued population growth.

Surface-Feeding Caterpillars

Caterpillars that feed in stored grain inhabit only the outer portions of the grain mass (usually the grain surface, but also the bottom of the grain mass just above perforated drying floors or aeration ducts). These caterpillars reach approximately $\frac{3}{4}$ inch in length and are cream-colored. They produce fine, silken webbing as they move about near the grain surface. Mature larvae pupate within a silky cocoon. Adult moths fly and mate in the bin headspace where they may be seen resting on the bin walls and roof.

Although the Mediterranean flour moth and the meal moth can be found in high-moisture conditions, the Indianmeal moth is the most common surface-feeding caterpillar in stored grain in Illinois. The adult Indianmeal moth has a wingspan of about $\frac{3}{4}$ inch; the outer half of each front wing is reddish-brown or copper-colored. Malathion resistance appears to be common in Illinois populations of Indianmeal moth.

Other Stored-Grain Insects

Additional pests that sometimes infest stored grains include psocids (booklice) and grain mites. These soft-bodied pests feed on grain-rotting fungi. An abundance of psocids or grain mites often indicates a more important problem of mold-related deterioration of the grain.

Remember that not all insects in grain are pests. Parasitic wasps, larvae of a predaceous fly species, and predaceous Hemipterans (true bugs) attack certain grain pests. In addition, many field insects are inadvertently transported to grain bins where they cause no damage.

PREVENTION OF INSECT INFESTATIONS

Sources of Infestations

Some stored-grain insects can infest maturing grain crops in the field. Although some field infestations probably do occur in Illinois, the extent of field-originated storage problems appears to be negligible.

The most common sources of stored-grain insects are old grain, grain spills, feeds, seed, and grain debris. Insects often move to new grain from carry-over grain, from small amounts of grain not cleaned from "empty" bins, from feed supply buildings, and from grain debris beneath perforated floors of bins. Most pest species can fly at least short distances to reach new grain.

Sanitation

To minimize the migration of stored-product insects from current food sources to new grain, thorough cleanup practices are necessary. At least 2 weeks before storing new grain, clean all grain and grain debris from within and around grain bins. Be thorough; sweep or vacuum bin floors. Also remove and feed or destroy any grain and grain debris in combines, wagons, augers, etc. If grain debris is not removed from the combine,

collect and feed or destroy the first few bushels of grain that pass through the combine.

Bin Sprays and Empty-Bin Fumigation

Insects may remain in certain bin locations even after a thorough cleanup is completed. Hard-to-clean sites that harbor insect pests include cracks and crevices in bin walls and the plenum beneath nonremovable perforated floors. Applying an insecticide or a fumigant in an empty bin can supplement (but not replace) physical cleanup efforts.

Apply an insecticide to the walls, ceiling, roof, and floor of all bins that will be used to store grain for more than a few weeks. Use

- 4 fl oz malathion 57% EC in 2 gal water;

or

- 1 qt methoxychlor 25% EC in 2 gal water;

or

- 12 oz methoxychlor 50% WP in 2 gal water;

or

- 4 fl oz Reldan 4E (chlorpyrifos-methyl) in 3 gal water.

Spray all bin surfaces to the point of runoff, and be sure to thoroughly treat all cracks and crevices and around doors. Directing extra spray to and through perforated flooring will provide some control of insects living in grain debris in the subfloor plenum, but satisfactory control of insects in this space requires fumigation (or removal of the false floor to allow complete cleanup of debris in the plenum).

Fumigating empty bins to control insects in the subfloor plenum may be necessary if summer-harvested grain (wheat, etc.) is to be stored in the bin 1 month or longer or if fall-harvested crops (corn, soybeans, or grain sorghum) will be stored beyond May or June of the year following harvest. The fumigant chloropicrin (trade names are Chlor-o-pic, Larvacide 100, and Quasar) is labeled and effective for empty bin fumigation. Use this fumigant only on relatively calm days when the outside air temperature is 65°F or higher.

Before applying chloropicrin, use tape and polyethylene sheeting to seal the side door and all bin openings below the level of the side door. Be sure to seal fan openings and the unloading auger shaft. Post warning placards according to label directions. Always have a partner present when applying this or any other fumigant.

To fumigate the subfloor plenum of empty bins, pour in chloropicrin from a ventilation door on the bin roof; use 1 quart per 250 square feet of floor area. Chloropicrin forms a pungent tear gas that settles in the lower portion of the bin. This gas will kill all stages of stored-grain insects beneath the subfloor, but chloropicrin will not spread to the upper portions of the bin to kill insects suspended in grain debris remaining on bin walls. Wait 24 hours before airing out the bin.

Chloropicrin is a restricted-use pesticide that is extremely toxic. The U.S. Environmental Protection Agency is reviewing and revising regulations concerning safety equipment (clothing, gloves, and respiratory protection) needed for the application of fumigants. Until updated regulations are published, rely upon the fumigant label directions for necessary safety precautions. If you are uncertain about the safe use of a fumigant, contact the manufacturer for detailed recommendations.

Filling the Bin

Effective insect management in stored grain starts with good grain storage practices. Use a grain cleaner to minimize the amount of fine material that is binned along with the grain. Many species of stored grain insects cannot survive in the absence of broken kernels and grain debris. Use a grain spreader to evenly distribute remaining fine material and to help level the grain surface. Once the bin is full, if fine material is concentrated in a central core beneath the auger spout, remove 1 or 2 loads from the bin in order to extract this core of fines. Do not add new grain on top of old because insects will rapidly move from the infested grain to the new crop. Do not overfill bins; the levelled grain surface should be at least 8 inches below the lip of the bin. Levelling the grain surface is important for uniform airflow and for effective insecticide or fumigant application.

Store only dry grain. Maintaining moisture levels that prevent the growth of storage fungi is sufficient where fall-harvested grain is to be stored only through the winter, but grains that will be stored 1 month or longer between May 1 and September 30 should be dried to 12-13 percent moisture. This moisture content is unfavorable for most grain insects; it also allows prolonged persistence of protectant insecticide residues.

Aerate to cool stored grain as soon as possible. Temperatures below 50°F prevent most insect feeding and reproduction. Cooling grain to just above freezing will kill some stages of many grain insects. Aeration also results in uniform temperatures that prevent moisture migration problems within a bin. Most grain storage references recommend aerating to maintain grain temperatures within 15°F of average outdoor temperatures. These references also usually discourage the use of aeration to cool grain below freezing.

Grain Protectants

Summer-harvested grains that are to be stored 1 month or more and fall-harvested grains that are to remain in storage beyond May and June of the year following harvest should be treated with a protectant insecticide. Where grain protectant insecticides are applied at labeled rates, grain can be processed or fed to livestock with no waiting period.

In order to protect against stored-grain beetles and weevils throughout the entire mass of grain within a bin, a protectant insecticide must be applied uniformly to all grain as it is augered into the bin. Drip-on or spray-on applicators can be mounted on the auger to apply liquid formulations. Dusts can be applied using an auger-mounted applicator, or they can be spread over a truck or wagon just before unloading. Protectant insecticides should not be applied to grain before high-temperature drying. Once grain is in the bin, surface or "cap-off" applications of protectant insecticides are effective only against the insects that are feeding at the grain surface. A surface dressing or "cap-off" treatment may be used to give some control of insects entering the top of the grain mass. Table 1 summarizes uses for registered grain protectants. Dichlorvos resin strips, although not applied directly to grain, also are listed in Table 1.

Crop-specific recommendations for the use of protectant insecticides are:

Corn. Apply malathion at the loading auger using rates listed in Table 1. Reldan is not registered for use on corn. Do not apply malathion before high-temperature drying because extreme heat will result in rapid volatilization and loss of malathion. For malathion residues to persist on corn at effective levels through the summer following harvest, corn must be dried to approximately 12 percent moisture.

Malathion will not control Indianmeal moth. Use *Bacillus thuringiensis* (*B.t.*) or dichlorvos resin strips to prevent Indianmeal moth infestations. Apply *B.t.* or hang dichlorvos strips at harvest or by May of the following year.

Soybeans. Only Indianmeal moth will infest soybeans stored at moisture levels that prevent mold growth. To protect against Indianmeal moth infestation, use dichlorvos resin strips or *B.t.* at harvest or by May of the following year. No other protectant insecticides are registered for application to stored soybeans.

Wheat. Wheat is especially vulnerable to insect infestation because it is harvested in mid-summer when stored-product insects are active within and outside storage facilities. Warm temperatures in summer-harvested wheat also contribute to the rapid development and reproduction of insects within bins.

Apply malathion or chlorpyrifos-methyl (Reldan) at the loading auger to all wheat that is to be stored for 1 month or more. Where malathion is used, also incorporate *B.t.* in the top 4-6 inches of grain or hang dichlorvos resin strips to prevent Indianmeal moth infestations. Chlorpyrifos-methyl controls Indianmeal moth and the weevils and "secondary" beetles that infest grain.

Sorghum. Apply malathion or chlorpyrifos-methyl at the loading auger, but not before high-temperature drying. For malathion residues to persist at effective

Table 1. Insecticides Registered For Use to Protect Stored Grain

Insecticide	Registered for use on:	Rate/1,000 bu	Restrictions; Comments
malathion 57% EC, 6% D, 4% D, and 2% D	corn, wheat, oats, barley, rye, sorghum, sunflower	1 pt 57% EC in 2-5 gal water; 10 lb 6% dust; 15 lb 4% dust; or 30 lb 2% dust. Use the same amount/1,000 sq ft of grain surface as a "cap-off" treatment *if the entire grain mass is not treated.*	Do not apply to soybeans. Malathion will not control Indianmeal moth. Dry grain to 12% moisture in order for malathion to persist for 1 year or more. Do not apply prior to high-temperature drying.
chlorpyrifos-methyl (Reldan 4E)	wheat, oats, barley, rye, sorghum, sunflower	barley — 9.2 fl oz; oats — 6.2 fl oz; rice — 8.6 fl oz; sorghum — 10.7 fl oz; wheat — 11.5 fl oz. Apply in 1-5 gal water.	Do not apply to corn or soybeans. Controls weevils, "bran bugs," and Indianmeal moth. Dry grain to 14% moisture in order for chlorpyrifos-methyl to persist for 1 year or more. Do not apply prior to high-temperature drying.
Bacillus thuringiensis (Bactospeine, Dipel, SOK-Bt, and Thuricide)	corn, soybeans, wheat, oats, barley, rye, sorghum, sunflower	Rate depends on product concentration. Follow label directions.	Use to control Indianmeal moth larvae. Controls only larval stages; must be ingested. Apply to the top 4-6 inches of grain as it is augered into the bin or incorporate by raking once the bin is filled.
pyrethrins plus piperonyl butoxide	corn, wheat, oats, barley, rye, sorghum, sunflower	Rate depends on product concentration. Follow label directions.	Do not apply to soybeans. Short-term residual activity. Useful mainly as a surface spray to control larval and adult Indianmeal moths as well as other pests at the grain surface.
dichlorvos 20% resin strip (Farm Strips, Vapona Strips, etc.)	corn, soybeans, wheat, oats, rye, barley, sorghum, sunflower	1 strip/1,000 cu ft of space above the grain mass.	Install once bin is filled or by May 15. Replace every 6-8 weeks from May to October. Effective only in closed bins; controls adult moths only.

levels through the summer following harvest, grain must be dried to 12 percent moisture content; chlorpyrifos-methyl (Reldan) will persist for 12 months or more on 14 percent moisture sorghum. Where malathion is applied, also use *B.t.* or dichlorvos strips at harvest or by May to control Indianmeal moth.

SAMPLING STORED GRAIN

Stored grain should be monitored regularly to determine grain moisture content and temperature and to detect any insect infestations. Sample stored grain for insects at least monthly from November through April and at least twice monthly from May through October. Pay particular attention to the grain surface and the central core of the grain mass, but also sample additional locations and depths. Be sure to examine grain from any locations where temperature or moisture readings are substantially higher than average. Deep bin probes and sectioned grain triers are most commonly used for withdrawing samples from beneath the grain surface. Probe traps and sticky pheromone traps also are available for monitoring insects within the grain mass and flying moths respectively. Sampling equipment is available from most bin sales and service companies.

CONTROLLING ESTABLISHED INFESTATIONS

When insects are found in stored grains, a logical question is "Are there enough insects present to warrant control?" Unfortunately, this question is hard to answer. The importance of an insect infestation is determined not only by insect numbers, but also by type of grain, insect species, time of year, grain temperature and moisture, the planned duration of storage, market potential, and local elevator quality and dockage guidelines. Federal Grain Inspection Service (FGIS) standards for grain insect infestation are presented in Table 2, but local elevators usually enforce more stringent standards. Insect-damaged kernels also may result in price discounts. Consider too that insect populations and their damage can increase rapidly.

When insects are detected in stored grain, consider several possible management practices. Sometimes the most profitable action can be to clean and sell the grain immediately without any chemical treatment. Immediate sale can be especially appropriate where early stages of insect infestations are detected before insect numbers reach elevator dockage or discount levels. During cool weather, aerating to cool the grain to below 50°F can prevent insect activity and allow an extended period of safe storage.

Table 2. The Number of Live Insects (per Kilogram of Grain) Required for FGIS Designation as "Infested"

Crop	Insect density for designation as "infested"
Wheat	• More than 1 live weevil, or • One live weevil plus any other stored grain insect pest, or • No live weevils, but 5 or more other live pest insects.
Corn, Barley, Oats, Sorghum, and Mixed Grains	• More than 1 live weevil, or • One live weevil plus 5 or more other live pest insects, or • No live weevils, but 15 or more other live pest insects.

Sometimes insect problems may be limited primarily to the surface or central core of stored grain. If Indianmeal moth is the only problem, light infestations can be controlled by using both *B.t.* and dichlorvos resin strips as outlined in Table 1. Where abundant webbing indicates a severe infestation, webbing should be raked from the surface before treating; fumigation may be necessary in these situations. Where bran bugs are confined primarily to a central core of fine material, removing 1 or 2 loads of grain to extract that core can allow safe storage of the remaining grain.

Where infested grain can be moved to a clean bin, transfer and treatment with a protectant insecticide (see Table 1) is recommended. If possible, use a grain cleaner during the transfer process. Protectant insecticides will not immediately kill immature insects within grain kernels, but residues will eventually provide control and protect against re-infestation for a period dependent upon grain moisture and temperature.

Infested grain that cannot be treated successfully in any other way should be fumigated. Before planning any fumigation, consider the following regulations:

- The use of any liquid fumigant containing ethylene dibromide (EDB) is now prohibited.
- As of December 31, 1985, the *sale* of any liquid fumigant containing carbon tetrachloride is prohibited.
- Grain owners may use existing supplies of fumigants containing carbon tetrachloride through June 30, 1986. Application of fumigants containing carbon tetrachloride is prohibited after June 30, 1986.

Suspension of most liquid fumigant registrations, coupled with increased safety concerns and protective equipment requirements for remaining fumigants, signal the fact that fumigation of farm-stored grain is a potentially dangerous and difficult operation. Hiring a professional fumigator is recommended, especially for fumigation of bins with capacities greater than 5 to 10 thousand bushels.

Fumigation Steps

1. Level the surface of the grain, break up any caked or crusted areas, and remove any surface webbing.

2. Use tape and plastic sheeting to thoroughly seal all cracks and holes in the bin; seal the eaves, hatches, side door, unloading auger shaft, and fan openings. Leave only the necessary access openings to seal after fumigant application.

3. Spray the outside surface of the bin with malathion (4 fl oz 57% EC/gal water), chlorpyrifos-methyl (4 fl oz Reldan 4E/3 gal water), or methoxychlor (1 qt 25% EC or 12 oz 50% WP/2 gal water).

4. Learn and follow all safety precautions. Always work in pairs; an observer should be present *outside* of the bin. The U.S. Environmental Protection Agency is reviewing and revising regulations concerning safety equipment (clothing, gloves, respiratory equipment, and gas-detection devices) needed for the safe application of fumigants. Until updated regulations are published, rely on the fumigant label directions for necessary safety precautions. If you are uncertain about the safe use of a fumigant, contact the manufacturer for detailed recommendations.

5. Choose a calm, warm day when the grain temperature is above 60°F. Apply a liquid or solid fumigant. Only those fumigants containing aluminum phosphide are registered for use on soybeans.

Common liquid fumigants containing carbon tetrachloride include carbon bisulfide + carbon tetrachloride (80:20 mixture) and ethylene dichloride + carbon tetrachloride (75:25 mixture). Use 3 to 5 gallons of these products per 1,000 bushels of grain; use the 5-gallon rate in wooden bins and flat storages. Use of fumigants containing carbon tetrachloride is prohibited after June 30, 1986.

Chloropicrin (Chlor-o-pic, Larvacide 100, and Quasar) is a restricted-use liquid fumigant labeled for probe and surface application to stored grain. Protective clothing and respiratory equipment must be worn during application. Use 2.5 lb/1,000 bushels of wheat, barley, or rice; 3.0 lb/1,000 bushels of corn; 3.5 lb/1,000 bushels of oats; or 4.5 lb/1,000 bushels of grain sorghum. Wait at least 72 hours before airing out; fumigated grain must be thoroughly aerated before processing or feeding.

Dry fumigants containing aluminum phosphide include Detia, Fumitoxin, Gastoxin, Phostek, and Phostoxin. Aluminum phosphide is a restricted-use fumigant. A special application probe is required to place aluminum phosphide tablets or pellets in the grain mass. Use 180 tablets or 300 pellets per 1,000 bushels of bin capacity. Do not allow water to come in contact with tablets or pellets; wear neoprene or cotton gloves to prevent perspiration from reaching the dry material. Gas released from pellets or tablets usually does not reach a dangerous concentration above the grain for 1 to 2 hours after application, but this period can be much shorter if grain is very warm or very moist.

6. Seal the access door that served as an exit from the bin. Place warning signs as directed by the fumigant label.

7. Where fumigants containing carbon tetrachloride were used, air out the bin after 24 hours. Wait at least 72 hours before airing out bins following aluminum phosphide or chloropicrin application; follow label directions.

An additional fumigant that is effective and registered for application to stored grain is methyl bromide. Because methyl bromide is a restricted-use fumigant that is applied as a gas, it is available only to professional fumigators.

Once it is aired out, fumigated grain is subject to reinfestation. Surface application of a protectant insecticide and/or placement of dichlorvos resin strips should follow fumigation if storge is to continue.

REFERENCES

Stored Grain Insects. 57 pp. USDA Agricultural Handbook No. 500. Available for $1.50 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Management of On-Farm Stored Grain. 92 pp. University of Kentucky Cooperative Extension Service. For single copies (free), write Dr. Harley Raney, Entomology Department, Agricultural Science Center, North, Room 5225, University of Kentucky, Lexington, KY 40546.

Fact Sheets available from Agricultural Entomology, University of Illinois, 172 Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820.

NHE 62 — Angoumois Grain Moth
NHE 63 — Indianmeal Moth
NHE 64 — Granary and Rice Weevil
NHE 65 — Grain and Flour Beetles

NOTES

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